Baseline Behavior of Pilot Whales and their Responses to Playback of Anthropogenic and Natural Sounds

Peter Tyack, Senior Scientist Emeritus
Biology Department
Woods Hole Oceanographic Institution
266 Woods Hole Road, MS#50
Woods Hole, MA 02543 USA
phone: (508) 289-2818 fax: (508) 457-2041 email: ptyack@.edu

Award Number: N000141210417

LONG-TERM GOALS

This project investigates the social ecology and baseline behavior of pilot whales, and their responses to anthropogenic and natural sounds. This project gathers data to help design and interpret controlled exposure experiments to pilot whales, with the ultimate goal of understanding responses to naval sonar and improving Navy environmental analyses.

OBJECTIVES

Our objectives here were to:

- Test whether it is feasible to instrument groups of pilot whales with acoustic and movement logging tags to investigate social dynamics and social cohesion mechanisms within pilot whale social groups.
- Develop and field test a stereo camera geolocation system for measuring the position of individual whales and estimating a robust quantification of group cohesion
- Conduct playback experiments to study responses of tagged whales to sounds of killer whales

APPROACH

This project supported a two-month field expedition to the Strait of Gibraltar, Spain, in collaboration with CIRCE (Conservación, Información y Estudio sobre Cetáceos). This field site is unique in that the year-round resident population of pilot whales (de Stephanis et al., 2008a) is relatively small, fewer than 200 individuals (Verborgh et al., 2009), and with very well-known social structure (de Stephanis et al., 2008c). ARGOS tags would be deployed on several individuals within the population to monitor long-term movement of groups throughout the field season. We selectively tag groups of pilot whales with acoustic and movement logging DTAGs (Johnson and Tyack, 2003), follow animals at the surface while conducting visual observations and quantifying social group cohesion using a stereo camera system under development, and to conduct playback experiments to a subset of the tagged animals when conditions are favourable.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2013		**00-00-2013 to 00-00-2013**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Baseline Behavior of Pilot Whales and their Responses to Playback of Anthropogenic and Natural Sounds	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,Biology Department,266 Woods Hole Road, MS#50,Woods Hole,MA,02543**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

WORK COMPLETED

Fieldwork was completed between July 2nd and August 31st, 2012. This expedition was highly successful, providing us with 33 DTAG deployments and a total of 184 hours of data. Two long-term satellite tags were deployed on groups within the strait, and reported movement of both groups over the ARGOS network throughout several months. We reported these accomplishments and preliminary results in the annual report from 2012. In 2013, we obtained funding from the Danish Council for Independent Research that allowed us to complete additional fieldwork in the Strait of Gibraltar. In total, this means that we have now deployed 63 tags on long-finned pilot whales in the area, including 7 highly cohesive groups of animals with 3 to 5 simultaneously tagged animals. All tagged individuals were fully identified previous observations and information from social association studies (de Stephanis et al., 2008c) and studies of foraging ecology using stable isotopes (de Stephanis et al., 2008b). This remarkable identification of animals and high resighting rate gave us a great flexibility in choosing the right animals at the right moment for tagging, and makes it very likely that we will be able to find and retag the same animals across field seasons. A working stereo camera has been designed and tested in the field, both with pilot whales and bottlenose dolphins, through 2013. The first results from this system are presented below.

RESULTS

Analysis of acoustic and movement data from tags is time-consuming. So far, two datasets have been completely analysed. An example of one of these datasets, collected in the end of August, 2012, is shown in figure 1. In this example, four tagged animals are shown, three (a,b,c) in the same subgroup. The foraging activity of the animals is readily identified through recordings of echolocation clicks and foraging buzzes, and these sounds seem to be produced at almost identical depths. Most of the dives shown here are synchronized in time, so that animals within the same subgroup dive together. During these dives, most communication sounds produced are short click series at high repetition rates, often called rasps (Aguilar Soto et al., 2012). These sounds seem to be important for short-range coordination, and through simultaneously tagged close associates, we are now able to start testing this hypothesis.

The two deployed ARGOS satellite tags have given us valuable information on long-term movement of animals in this region. Figure 2 shows a plot of the transmitted high-quality locations of the two tagged individuals during summer 2012 expedition. These animals seem to have a small home range, which confirms data collected through visual surveys in the area (de Stephanis et al., 2008a). However, we were lucky to record a multi-day excursion out of the bay, to a deep canyon (Ceuta canyon) off the east coast of Morocco. The frequency that these excursions occur at, and the role that they play for these pilot whales remains unknown, though.

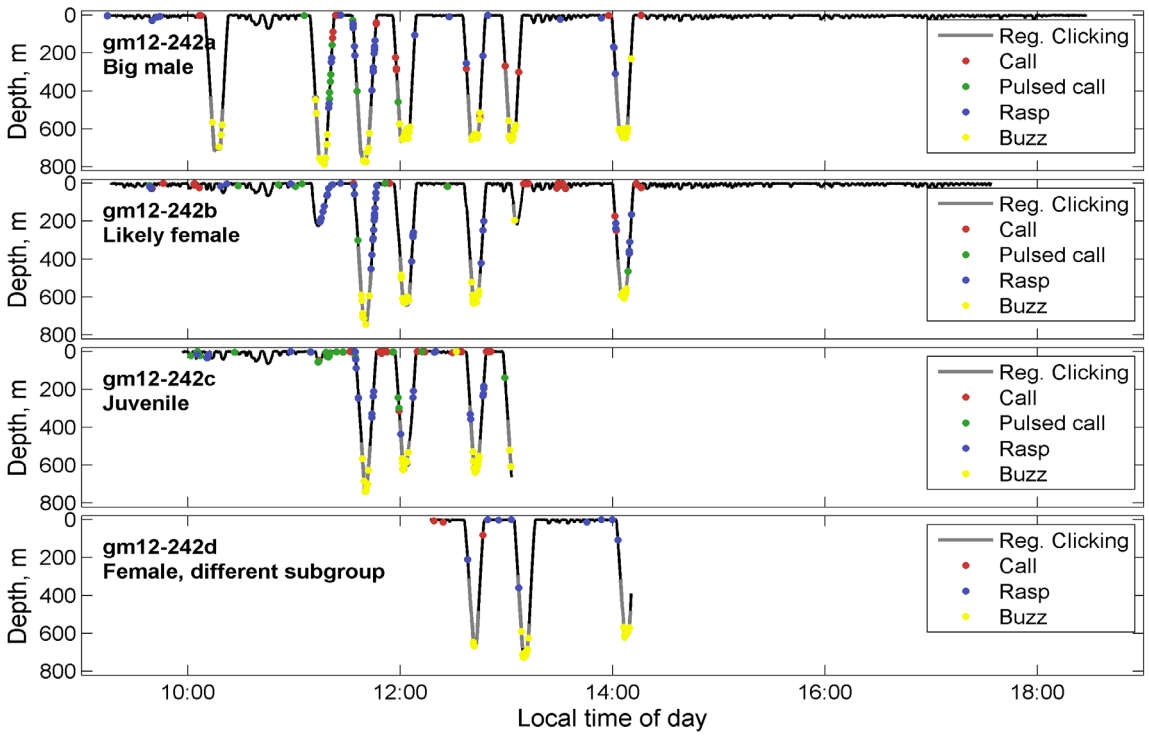

Fig. 1: Dive profiles annotated with sound production for 4 simultaneously tagged animals

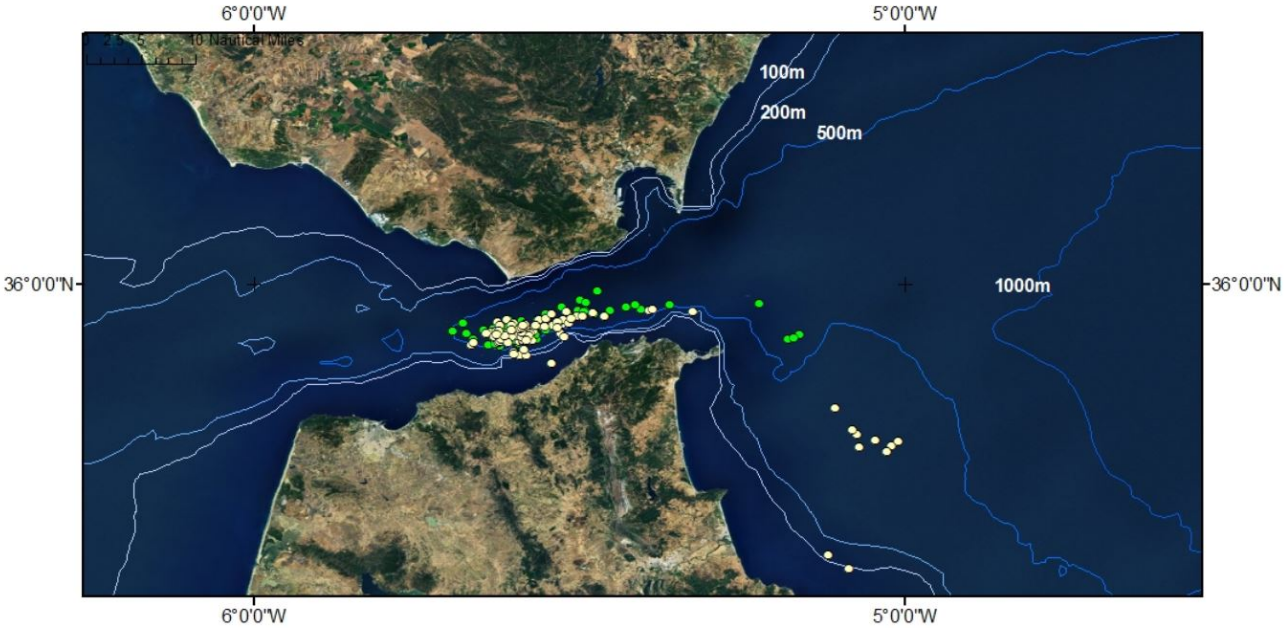

Figure 2: ARGOS transmitted locations for two long-finned pilot whales tagged during summer 2012 expedition. Most of the study period, animals remained in a relatively small area in the south of the Strait of Gibraltar, but the animals curiously made a multi-day excursion to the east, into Ceuta canyon.

In 2013, we also revised the camera system under development for quantifying surface group movement and social cohesion of cetaceans (Figure 3), including adding a time-synchronized audio recorder for labelling each animal as it surfaces. The system works well under relatively calm sea states. Figure 4 shows a brief (20 minute) plot of the movement of 6 animals within the same group. We are testing different methods for modelling the position of animals between surfacings, giving us a higher time resolution of the 2D location of animals, interanimal distances and mean group dispersion (Fig. 5), and more reliable estimates of speed-over-ground and animal orientation.

Figure 3: The current stereo geocoding system for 3D localization of whales and quantification of social group cohesion. Left: Example of stereo camera system used in August 2012 field cruise, sampling at 4 Hz. Center: Image of 3 pilot whales similar to what is captured by a single of the two cameras. Images from both cameras are analysed to find a distance to different whales using the known aperture and calibration values, and then combined with the GPS position and pointing vector of the camera to calculate georeferenced positions. Right: Conceptual illustration of geocoded position estimates of the three animals shown on image in the bottom left. An initial RMS measure of social group cohesion could be derived as the root-mean-squared distance from each whale (dorsal fin location shown in blue circles) to the mean group position (red circle), for a mean group spread of 4.05 m in this example, and with individual distances between animals noted on figure. Range resolution for the current system is better than ±1m at 50 meters distance.

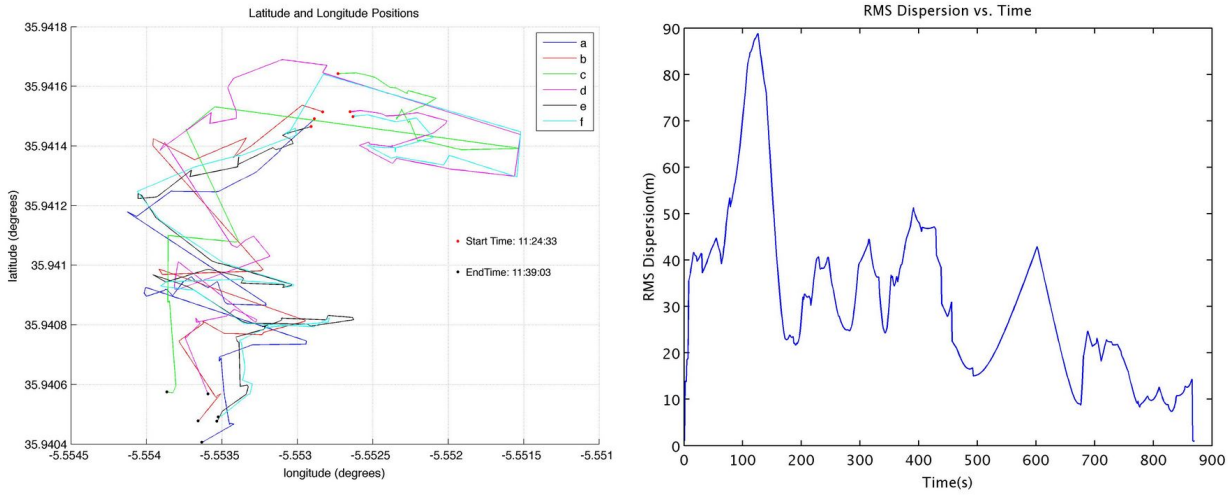

Figure 4: Movement and cohesion of a group of six long-finned pilot whales, measured with a stereo camera. Left: Individual positions (latitude and longitude) measured for all six animals over the course of 20 minutes. Right: RMS group dispersion over time for the six animals tracked with the stereo camera, representing the mean of the distances from the centre of the group to each individual.

IMPACT/APPLICATIONS

An important research topic for the ONR Marine Mammals and Biology program is to study the responses of beaked whales and other whales to naval and anthropogenic sounds. This study is important for this on several levels: First, an increased understanding of the behavior and acoustic signalling during different degrees of social group separation provides an important baseline for interpreting and designing controlled exposure experiments to pilot whales. For these and other gregarious cetaceans, the group composition, spatial distribution and foraging activity presumably modulates the likelihood of response of individuals exposed to playbacks. Second, an important response variable for social delphinids exposed to disturbance is acoustic activity (DeRuiter et al., 2012) and data on individual and group social communication during different behavioral states may help us better interpret the importance of changes in social signalling. Third, an important variable for responses is changes in orientation and movement (Pirotta et al., 2012; Tyack et al., 2011) and directional approach or avoidance responses (Curé et al., 2012). The stereo camera system under development as part of this project is capable of measuring orientation and speed of animals, as well as quantifying changes in group cohesion that might be part of a possible defensive response to a disturbance.

RELATED PROJECTS

The 3S project and BRS AUTEC projects conducted controlled exposure experiments to pilot whales. The 3S project played back sounds of familiar fish-eating killer whales to pilot whales; this project uses sounds of unfamilar mammal-eating killer whales. We have provided data on our playbacks to 3S, filling a data gap from 3S. An earlier ONR project entitled Tagging and Playback studies of toothed whales (N000140910528; PIs: P. L. Tyack and A. Bocconcelli) preceded this project with previous work on long-finned pilot whales in the Alboran Sea. One of the biggest problems in analyzing

responses to playback involves high levels of variability in baseline behavior. This project seeks to understand the underlying factors and context that cause this variability. We are also making data from this project available to the MOCHA project – "Multi-study ocean acoustics human effects analysis," award number N000141210204, so that they can use the data for innovative statistical analyses, and can pool the data with those from other studies in integrative analyses. The MOCHA project (http://www.creem.st-and.ac.uk/mocha/) will use data from all of these projects as they develop new statistical methods to analyse these kinds of data within and across studies.

REFERENCES

Aguilar Soto, N., Madsen, P. T., Tyack, P., Arranz, P., Marrero, J., Fais, A., Revelli, E. and Johnson, M. (2012). No shallow talk: Cryptic strategy in the vocal communication of Blainville's beaked whales. *Marine Mammal Science* 28, E75-E92.

Curé, C., Antunes, R., Samarra, F., Alves, A. C., Visser, F., Kvadsheim, P. H. and Miller, P. J. O. (2012). Pilot Whales Attracted to Killer Whale Sounds: Acoustically-Mediated Interspecific Interactions in Cetaceans. *PLoS ONE* 7, e52201.

de Stephanis, R., Cornulier, T., Verborgh, P., Salazar Sierra, J., Gimeno, N. P. and Guinet, C. (2008a). Summer spatial distribution of cetaceans in the Strait of Gibraltar in relation to the oceanographic context. *Marine Ecology Progress Series* 353, 275-288.

de Stephanis, R., García-Tíscar, S., Verborgh, P., Esteban-Pavo, R., Pérez, S., Minvielle-Sebastia, L. and Guinet, C. (2008b). Diet of the social groups of long-finned pilot whales (*Globicephala melas*) in the Strait of Gibraltar. *Marine Biology* 154, 603-612.

de Stephanis, R., Verborgh, P., Perez, S., Esteban, R., Minvielle-Sebastia, L. and Guinet, C. (2008c). Long-term social structure of long-finned pilot whales (Globicephala melas) in the Strait of Gibraltar. *Acta Ethologica* 11, 81-94.

DeRuiter, S. L., Boyd, I. L., Claridge, D. E., Clark, C. W., Gagnon, C., Southall, B. L. and Tyack, P. L. (2012). Delphinid whistle production and call matching during playback of simulated military sonar. *Marine Mammal Science*, Published online before print: 19 July 2012.

Johnson, M. P. and Tyack, P. L. (2003). A digital acoustic recording tag for measuring the response of wild marine mammals to sound. *Ieee Journal of Oceanic Engineering* 28, 3-12.

Pirotta, E., Milor, R., Quick, N., Moretti, D., Di Marzio, N., Tyack, P., Boyd, I. and Hastie, G. (2012). Vessel Noise Affects Beaked Whale Behavior: Results of a Dedicated Acoustic Response Study. *PLoS ONE* 7, e42535.

Tyack, P. L., Zimmer, W. M. X., Moretti, D., Southall, B. L., Claridge, D. E., Durban, J. W., Clark, C. W., D'Amico, A., DiMarzio, N., Jarvis, S. et al. (2011). Beaked Whales Respond to Simulated and Actual Navy Sonar. *PLoS ONE* 6, e17009.

Verborgh, P., De Stephanis, R., Pérez, S., Jaget, Y., Barbraud, C. and Guinet, C. (2009). Survival rate, abundance, and residency of long-finned pilot whales in the Strait of Gibraltar. *Marine Mammal Science* 25, 523-536.

PUBLICATIONS

Fenton BMB, Jensen FH, Kalko EKV, Tyack PL. (book chapter) Sonar Signals of Bats and Toothed Whales. In: Biosonar (eds: P. E. Nachtigall, A. M. Surlykke, A. N. Popper, R. R. Fay). Springer, New York (Springer Handbook of Auditory Research). [in press, refereed]

Sayigh L, Quick N, Hastie G, Tyack P. 2012. Repeated call types in short-finned pilot whales, *Globicephala macrorhynchus*. *Marine Mammal Science*, DOI: 10.1111/j.1748-7692.2012.00577.x [published, refereed]

Shamir L, Yerby C, Simpson R, von Benda-Beckmann A, Tyack P, Samarra F, Miller P, Wallin J. (submitted) Quantitative analysis of killer and pilot whale sounds using Whale FM. *J. Acoust. Soc Am.* [submitted, refereed]

Tyack PL, Janik VJ. (book chapter) Effects of noise on acoustic signal production. In Animal Communication and Noise. (Brumm H, ed) Springer Verlag, Berlin. [in press, refereed]